Bamboo Industry Development Plan
for Devikulam

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EXECUTIVE SUMMARY

This report aims to improve the employment prospects for the Devikulam community by proposing a Bamboo Industry Development Plan for the region. Currently the people of Devikulam rely on the prawn and agricultural industries as their main sources of employment and income. However, there are social and environmental problems associated with each of these industries. The Industry Development Plan we have developed addresses these problems and seeks to mobilise the community of Devikulam by using their current agricultural skills to cultivate, harvest and market Bamboo.

Initially, we created a list of design requirements that we felt a viable, sustainable and culturally appropriate industry should fulfil. After considering and exploring various options throughout the design process, we concluded that a bamboo industry best satisfied these requirements. Our report documents how we have adequately addressed each of these criteria in our research and planning processes.

Overall we feel this report both justifies the development of a bamboo industry in Devikulam and offers a comprehensive plan on how achieve it.

TEAM REFLECTION

We began the 2011 EWB Challenge faced with nothing new. In this way, we were confronted with issues concerning poverty, development and sustainability; issues toward which we have become largely desensitized. In this case, however, we were afforded with an opportunity to not only consider such issues in abstract terms, but to respond to such with practical solutions. We, as students, found this to be empowering.

In the first instance, it must be noted that like most members of contemporary Western society, we struggled to understand how seemingly simple solutions to profound problems haven’t yet been implemented by the community of Devikulam. In all honesty, our lack of understanding led to frustration. From this point, however, we began to consider the idea that what may be a ‘problem’ for us, may not be a problem for others. Open defecation, for example. Indeed, we came to realise that the issue of ‘development’ must be considered in the same light. That is, the ‘development’ of or for one, may not be, or result in the ‘development’ of or for another. Development is a subjective term. Development is a relative term. So, then, is ‘sustainability’. By framing the discourse in this way, our collective thinking became more culturally sensitive and appropriate. From this, we worked to design and hopefully implement effectively sustainable solutions in response to the challenges facing Devikulam.

A key point arose from our re-conceptualised notions of development and sustainability. We realised that a sustainable and viable design is not simply technically so. Rather, a sustainable and viable design is one which meets both the technical requirements of the problems it seeks to address, and the cultural demands of the community.
The next challenge we faced came when we were asked to choose focus groups based on the design brief. In this way, very few of us had formed a solid idea of where we would like to work. We struggled to identify and define a problem given the broad nature of the challenge. This however, didn't stem from indifference or disinterest. Rather, we found it difficult choosing a project area which we feel, above others, required attention.

We also faced challenges concerning originality and innovation. Whilst exploring our first design option of Bamboo Bikes, we discovered that a similar project had been implemented by Columbia University in Africa. It was a hurdle that, at first, had us feeling defeated. We came up with the idea of bamboo bikes organically, so it had felt original and innovative. This provided us with plenty of enthusiasm in the initial research and design processes. Knowing, however, that our design wasn't entirely original crushed these feelings of enthusiasm. From this point, we rediscovered our collective sense of purpose by returning to our original design requirements and the design brief. We found visualisation methods extremely useful in overcoming these obstacles. Upon facing such obstacles we were faced with the challenge of perceiving, or re-conceptualising our design solutions. Re-conceptualising challenges in this way assisted in overcoming adverse elements of the design process.

Individually, each of us overcame various and contrasting obstacles. Though, we found that by exploring them together we gained solidarity, focus and vision. This highlights the importance of honesty and transparency in group situations. Had we not indicated to the group doubts we were having, and instead just let them remain insidiously underlying, most of our doubts would not have been alleviated, and the effectiveness of our eventual design would ultimately have been compromised.

As a group of 7, we learnt early of the importance of delegation in group environments. We managed to divide the design process into various different stages and define each member's roles and responsibilities in regards to the final proposal. Dividing the project into manageable and measurable chunks such as this held each member more accountable, which in a large group such as ours, was of added importance. Again, visualisation methods and timelines assisted in achieving this.

Our eventual design looks little like the one we first envisioned. From the ‘whiz-bang’ solutions of 3 months ago, our project has become a multifaceted, viable and sustainable solution to Devikulam’s developmental needs. Of equal importance are the relationships we have forged as a group. Mere strangers of various disciplines have become unlikely friends. We have learnt much of ourselves, each other, Devikulam and the design process itself. We can safely say, however that we, and hopefully Devikulam are better for it.
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Devikulam's environment, and without exploiting their current resources.

Be environmentally friendly by ensuring there is no contamination of Devikulam's environment, and without exploiting their current resources.

Generate local employment for a range of people, thus improving the yearly income per capita in the Devikulam community.

Utilize the skills that the people in the community have already developed.

Have a low initial and maintenance cost.

Ensure the sustainability of the industry.

Cost analysis

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1 Problem definition

1.1 Problem scope

The community of Devikulam has a range of problems stemming from their low-income jobs in agriculture. Many are unemployed and do not earn an income. This has created a continuous cycle where the lack of a decent income hinders villagers from accessing education and improving the lives of the both their current and future generations, causing the next generation to follow in the same footsteps. Improved wealth is crucial to breaking the poverty cycle because from there, communities can take control of and improve their own lives. They would be able to afford to send their children to secondary school where they could learn about health, the environment, family planning, women empowerment, and further opportunities and prospects they can grasp after completion of their studies. The creation of income generating responsibilities for women in particular increases their social place in society and leads to greater influence and weight in their society and homes. In addition, people can improve their own standard of living by affording improvements to their homes and nutrition, as well as being able to afford services such as health services and transport. Increased affluence empowers the people of Devikulam to take control of their individual lives. Our project aims to address this fundamental problem to their current situation by creating a sustainable, functional industry for the people of Devikulam to develop.

1.2 Technical Review

1.2.1 India

The Republic of India occupies a large portion of the South Asian subcontinent and is the 7th largest country in the world. The climate of India is broadly classified as tropical monsoonal and is characterised by typically high temperatures and dry winters. The four seasons are Winter (December to February), Summer (March-June), South-West monsoon season (June-September) and post monsoon season (October-November) (Indian Government, 2011).

According to provisional 2011 Census, there are over a billion people in India, with a 17% growth rate since 2001. The country's literacy rate is 74%, and the average life expectancy in India is 63.9 years (Indian Government, 2011). It must be noted that 27.5% of India's total population live below the poverty line (World Bank, 2009). Also, about three-quarters of its population reside in its 600,000 villages with 170,000 of these being located in the vicinity of forests (Wang, 2006). In this way, most Indians rely on their surrounding forests to meet their most basic needs (Wang, 2006).

1.2.2 Tamil Nadu

Tamil Nadu is the seventh most populous state with a population of over 60 million, over half of which live in rural areas. As a percentage of its total population, the Scheduled caste population accounts for 19%, which is more than the rest of India. The temperature on the plain ranges of Tamil Nadu ranges from 21 to 36 degrees, whilst normal rainfall is around 911.6mm per annum. There is a total cultivated land area of 5,571,718 ha in Tamil Nadu. Also, there is 21431.114 sq
km forest area, 19214.476 of which are reserved. In regards to the out turn of forest produce, bamboo equates to approximately 1254.299 metric tonnes. This however, equates to less than that of the out turn of babul, tamarind, total pulpwood, firewood and teakwood (Government of Tamil Nadu, 2008).

### 1.2.3 Devikulam

Devikulam is a village of Nadukuppam Panchayat in the Viluppuram District of Tamil Nadu. There are approximately 358 people or 86 families in Devikulam. Household occupancy generally ranges from between 4 to 7 people. The community is split between the village and the colony. Most village residents own between 2-5 acres of land. Contrastingly, only 3 households in the colony own around ¼ acre each. The households themselves are mostly hut style, comprising of cement or mud floors, mud or burnt brick walls and thatched or palm leaf roofs. The Government has provided housing to the Scheduled Caste under the Group Housing Scheme. These are made from burnt brick and concrete, but like other houses in the town, are in need of maintenance. In this way, Devikulam's infrastructure is poor in the village and most people live below the poverty line (EWB, 2011).

Devikulam also has 3-4 acres of common, public land. There are, however, problems regarding the land in Devikulam. Whilst the ground water level is relatively high, increasing salinity and its subsequent effects on the drinking water are concerning (EWB, 2011). Of additional concern is the salt-water contamination, which occurred following the 2004 tsunami (EWB, 2011).

Agriculture is the main industry in Devikulam. As most village residents own their land, many cultivate crops such as tapioca, rice, sugar cane, ground nuts and watermelon. These residents generally work over 20 days per month, and the annual income per village household ranges from Rs 10,000- 60,000. Colony residents, however, generally work as labourers for external farms between 11 and 20 days per month. Their annual is significantly less, ranging from Rs 15,000- 30, 000. An old age government pension of around Rs 400 per month is the main income for a few houses. Many residents have also left Devikulam seeking greater financial and employment opportunities (EWB, 2011).

The nearby Prawn industry also provides Devikulam with revenue. Though, the employment opportunities created by this industry are mostly given to outsiders. This industry also negatively impacts the environment of the region through its excessive use of ground water and electricity. Such has contributed to ground water contamination which affects local agricultural plots. In this light, Pitchandikulam Forest aims to improve employment prospects for Devikulam. EWB suggests doing so by developing new forms of industry for the region. That said, there is no current Industrial redevelopment plan for Devikulam (EWB, 2011).

### 1.2.4 Suitability of Bamboo in Devikulam

According to EWB's Small Enterprise Options Assessment of Devikulam, there is a sufficient supply of bamboo for at least five years to warrant rural enterprises in the region. Additionally, this assessment concludes that growing eco-awareness amongst the community has resulted in positive conceptualizations of bamboo. In this way, it is seen as an eco-friendly alternative to household furniture and others items. This can partly be attributed to the JFM scheme which between 1997-2004, saw the Government of Tamil Nadu plant bamboo in local forest areas as
one of its community asset creation crops (EWB 2011).

The value of both internal and commercial uses of bamboo globally is calculated to be approximately $10 billion AUD. This number is expected to reach $20 billion by 2015. Currently India’s share of this market is estimated at $1 billion. Estimates suggest, however, that India has utilised only a tenth of its bamboo-producing potential (Wang, 2006).

The National Bamboo Mission in Tamil Nadu provides further incentive for the establishment of a bamboo industry in Devikulam. This 100% funding scheme is being implemented by the Indian Government through the Tamil Nadu Horticultural Development Agency (TANHODA) in an effort to expand the Indian market to approximately $5.5 billion by 2015 (Wang, 2006). During 2009-2009 alone, it was implemented to cover an area of 1006 ha for a financial outlay of only Rs.202 lakhs (Wang, 2006). In this way, the Indian Government has acknowledged the employment generating capabilities of bamboo (Wang, 2006). It has promoted bamboo as both a key forest product and a means of raising the standard of living for rural Indian communities.

Bamboo is an ideal economic investment that can alleviate many environmental and social problems facing Devikulam. In this way, bamboo's extensive rhizome-root system and accumulation of leaf mulch can prevent soil erosion, conserve moisture reinforcement of embankments and drainage channels during monsoon season. The implementation of bamboo to Devikulam, as part of an Industry Development Plan, would also address the increasing salinity. Additionally, bamboo generates oxygen, lowers light intensity, is an atmospheric and soil purifier, conserves soil moisture and reduces drought effects on flora and fauna (Nath, 2009).

There is also a high demand for Bamboo in the Indian commercial and industrial markets. Commercially, 2.5m live culms are widely distributed, whilst bamboo of 3 to 9m length is predominantly used industrially, particularly in the construction of houses. India has also been exporting bamboo on a large scale. In particular, it exports value added products, which it also imports, but the export of bamboo as a raw material is not permitted. In many parts of India, homestead bamboo is a major source of income for villages (Rawat & Khanduri, 2001).

Currently, however, bamboo is an under managed and over exploited resource base (Wang, 2006). There is great potential for further development of the bamboo industry in both India, and Devikulam.

2 Design requirements

2.1 Generate local employment for a range of people, thus improving the yearly income per capita in the Devikulam community.

2.2 Utilize the skills that the people in the community have already developed.

2.3 Have a low initial and maintenance cost.
2.4 Be environmentally friendly by ensuring there is no contamination of Devikulam’s environment, and without exploiting their current resources.

2.5 Ensure the sustainability of the industry.

3 Design Options

3.1 Detail of option 1: The Bamboo Bicycle
Initially, we narrowly focused on trying to establish a ‘Bamboo Bicycle’ industry in Devikulam. On top of tackling issues related to industry, it also dealt with developmental concerns in transportation and education. This was because we identified that a lack of education generally leads to a lack of awareness in all areas, such as health, sanitation, employment options and the adoption of unsustainable practices. Although there is a local primary school, the nearest secondary school is located in the neighbouring city, Nadukappam; about 4km away. Because of this, most Devikulam children only have a primary school education as the lack of transportation options means that the secondary school is just too far to access. Bikes are one of the most affordable and sustainable forms of transportation as it requires no emission of greenhouse gases. It is also the most viable transport to introduce to Devikulam as they already have a limited number of bikes, though they are only used by a select few men. Additional bicycles would allow more farmers to sell their produce in the markets of Pondicherry more frequently, and give the village access to health care and other recreational centers, as well as education.

In relation to the bamboo industry, manufacturing bike frames made of bamboo requires cheaper infrastructure, less electricity and less equipment (i.e. less resin is needed) than steel frames. The final product is stronger (when it splits it does not completely break apart like steel does, ensuring the temporary safety of the rider), lighter and better suited for riding on unpaved, land roads, like one out of the two connected to Devikulam. They are also more easily modified for user needs, for instance carrying loads and passengers.

As we learned, ‘sustainable development’ is when ordinary people get control over their own development, and so to ensure that the development of the bamboo bicycles is sustainable, we suggest teaching the community to make the bicycles themselves, as opposed to just giving Devikulam more bikes.

The broader implementation of a bamboo industry was favoured over the Bamboo Bike Project because the latter felt too narrow and possibly a little imperialistic. In this way, the Bamboo Bike Project did not allow much room for exploration or choice for the people of Devikulam. It also did not meet a few design requirements, such as a ‘low start-up cost’, especially when we had to take into consideration that bamboo was not available in Devikulam itself, so ensuring a high cost of imports. Thus we concluded, that to establish a Bamboo Bike industry, we would first have to implement a bamboo industry in order for our project to be realistic and viable. The opportunity for a Bamboo Bike industry is better seen as a future prospect after the bamboo industry has been established, and will be further explored in Additional Uses and Next Steps.
<table>
<thead>
<tr>
<th></th>
<th>COSTS</th>
<th>Environmental impact</th>
<th>Community opinion</th>
<th>Appropriateness of design</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPTION 1 (Keep current industry)</td>
<td>No cost</td>
<td>Negative environmental impacts associated with the prawn industry – contamination of ground water and marine environment.</td>
<td>Indifference but this is most likely down to the their lack of education at the employment and income opportunities available to them should they explore other industries.</td>
<td>&gt; Jobs aren’t predominantly targeted at the people in Devikulam in comparison to other areas so this industry does not create plentiful job opportunities.</td>
</tr>
<tr>
<td>OPTION 2 (Bamboo bike industry)</td>
<td>Initial costs and maintenance- $65,000 Sourcing ($20,000) to identify established metal parts vendors and other quality parts in order to establish an effective supply chain. Development ($30,000) to make and refine tools that ensure bikes can be mass-produced in a reasonable time-period. Training and Set-up ($15,000) to transfer the technology required to India and train workers.</td>
<td>➢ environmentally friendly mode of transport ➢ Resins used have a detrimental effect on the environment</td>
<td>&gt; community are already familiar with using bikes however, because this industry is so specific, if the community reject the idea from the start it will not be possible to implement.</td>
<td>&gt; although the end result would be a sustainable form of income for the community as well as the production of an environmentally friendly mode of transport, the implementation process would be costly considering the materials needed to produce the bikes.</td>
</tr>
<tr>
<td>OPTION 3 (Bamboo industry)</td>
<td>➢ growth of bamboo has positive environmental impacts that help against the affects of deforestation. ➢ Boric acid treatment is environmentally friendly</td>
<td>&gt; Community acceptance is likely considering the skills needed to maintain and create this industry are ones that the people of Devikulam already have due to their experience with the agricultural industry</td>
<td>&gt; the bamboo industry fits our design requirements as it provides a solution that is sustainable, creates jobs, is environmentally friendly and has a low start up cost relative to other options.</td>
<td></td>
</tr>
</tbody>
</table>
4 Final design solution for Devikulam Industry

4.1 Summary of the design

We have designed a bamboo-focussed Industry Development Plan for Devikulam. The design offers comprehensive solutions regarding the growing, harvesting, treating, drying and marketing processes involved in the development of this industry. Additionally, the solution incorporates a design for a warehouse which we believe will effectively assist in the cultivating and harvesting processes. The design warehouse will also offer increased employment and revenue opportunities for Devikulam. It must also be noted that as part of our solution we have designed a provisional framework regarding the appropriate forms of community engagement required in ensuring our design is a viable one.

5 Detailed description

We used a flow chart to clearly display the steps that would have to be taken in order to establish and maintain a functional bamboo industry in Devikulam. The implementation of this process into the community is considered in the next section of our report.

![Flow Chart]

Bamboo is an extremely versatile, strong, renewable and environmentally friendly plant. It is one of the fastest growing plant species, and can grow and adapt to a wide variety of climatic and edaphic conditions. Bamboo is an endlessly renewable resource and can be harvested sustainably in a 3-5 year cycle. It is an excellent alternative to wood and has the potential of being a carbon sink, thus helping in countering the emission of green house gases. The bamboo root systems stay intact after harvesting which helps to prevent erosion of soil and damage to the environment. It is also intricately involved in the ancient arts and culture of India, being used as a medicinal plant, a food source and a critical element of the economy (Liese, 1998).

Given its unrivalled position in terms of diversity, distribution and uses, coupled with the vital role it plays in the rural economics of India, bamboo has emerged in recent years as potentially the most important non-wood forest resource to replace wood in construction and other uses (Liese, 1998).

5.1 Habitat and Distribution:

Bamboos are usually found in moist valleys, sheltered depressions, along streams and on lower hill slopes, but occasionally occur also on higher slopes and hilltops. Bamboo is found
throughout India. Depending on the environmental conditions, different species prefer different climates and soils. Although there are over 1,000 species of bamboo, we have chosen to consider eight of these that we know to flourish in Indian soils (Table 1).

Table 1: Comparison of eight species of bamboo (Dun, 1998)

<table>
<thead>
<tr>
<th>Species and Local name</th>
<th>Soil</th>
<th>Topography</th>
<th>Description of Species</th>
<th>Climatic conditions &amp; Occurrence</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arundinacea racemosa - Maling</td>
<td>Gravelly loam &amp; clay loam</td>
<td>Slopy upland &amp; high relief</td>
<td>This hill bamboo is found at an elevation of 3000-3700 m, where it forms a very dense undergrowth. Culms are 1.5-4.5 m high, with a diameter of 2.5cm or less.</td>
<td>Moist, Eastern Himalayas 2200-3050 m alt.</td>
<td>Roofing, matting, fencing, props etc.</td>
</tr>
<tr>
<td>Bambusa bambos - Bhaluka - Balku bans</td>
<td>Plain catchment, river sand, fertile soil</td>
<td>River bank, hilly moist area</td>
<td>This is a tall bamboo with dull grayish-green culms, 15-23 m high and 8-17 cm in diameter.</td>
<td>Moist, everywhere except dry land and arid regions of India</td>
<td>Rafters, house posts, ladders, tent poles, shafts of tongas, mats, baskets, scaffoldings etc; also used for pulping; seeds and shoots are used as food.</td>
</tr>
<tr>
<td>Bambusa tulda - Tulda - Peka - Mak</td>
<td>Catchment, Sandy fertile soil</td>
<td>Plain land near water source</td>
<td>Straight culms with large leaves on upper branches, grows to a height of 15 m with a diameter of 8 cm.</td>
<td>Moist, Assam, W. Bengal, Central India, Moist Deccan plateau, Deciduous forest areas</td>
<td>Considered one of the most useful bamboos. Used for building purposes, scaffolding and roofing, and paper pulp.</td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td><strong>Soil</strong></td>
<td><strong>Terrain</strong></td>
<td><strong>Height &amp; Diameter</strong></td>
<td><strong>Location</strong></td>
<td><strong>Uses</strong></td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>--------------------</td>
<td>----------------------------</td>
<td>---------------------------------------------------------------------</td>
<td>-----------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Bambusa striata/vulgaris - Basini Bans - Kalaka - Ponmungil</td>
<td>Sandy fertile</td>
<td>Coastal region, plains</td>
<td>Moderate sized bamboo 6-10 m in height and 5-8 cms in diameter, with yellow or green striped culms.</td>
<td>Moist. North-East, M.P. and other moist areas</td>
<td>Used for furniture, toys, cages, construction etc.</td>
</tr>
<tr>
<td>Dendrocalamus hamiltonii - Kokua - Pecha - Kaghzi bans</td>
<td>Fertile loamy soil</td>
<td>Hilly and river bank</td>
<td>A large bamboo with culms often over hanging. 25 m long and 10-18 cm diameter; it is thin walled</td>
<td>Moist, North-Western Himalayas, Eastern India up to 1000m alt. in moist deciduous forest areas</td>
<td>Used for paper manufacturing, construction, baskets, mats, rafts and water vessels.</td>
</tr>
<tr>
<td>D. giganteous</td>
<td>Fertile, sandy loam, loam.</td>
<td>Plain land and also hilly areas</td>
<td>Largest of the bamboos with a height of 24-35 m and 20-30 cm in diameter.</td>
<td>Moist, Arunachal Pradesh, Assam, Manipur, Nagaland and W. Bengal</td>
<td>Used for building purposes, water buckets, boxes, masts of boats, flower vases etc.</td>
</tr>
<tr>
<td>D. strictus - Narbens - Nanvel - Salia bhanso - Kalmungil - Sadanapa veduru</td>
<td>Gravely degraded land, shallow soil</td>
<td>Slopy hills &amp; dry degraded plain land</td>
<td>Culms are 8-16 m high and 2.5-8 cm in diameter. Almost solid or internodes are think walled.</td>
<td>Dry, all over India up to 1000 m alt.</td>
<td>Used extensively for house construction, baskets, mats, furniture, agriculture implements etc. An important raw material for paper and rayon in India.</td>
</tr>
<tr>
<td>Melcanna baccifera</td>
<td>Fertile, loam</td>
<td>Slopy hills, bunds of cultivated lands</td>
<td>Culms do not form clumps, they are straight, thin walled and attain a height of 10-20 m and a diameter of 4-7 cm.</td>
<td>Moist, entire North-East, W. Bengal and hilly areas</td>
<td>Used for construction, baskets, mats, toys etc. Important material for superior paper pulp.</td>
</tr>
</tbody>
</table>

### 5.2 Description of Species:

#### 5.2.1 Bamboo Morphology:

Bamboo consists of a rhizome at the base of the plant, the culm that travels from the base to the tip of the plant, and the culm sheath that is attached to the nodal joints of the bamboo (Figure 1.)

Figure 1. Parts of the Bamboo plant

Figure 2. Sympodial (clumping) and monopodial (running) rhizome branching

**Rhizome:** can be either sympodial (clumping bamboo) or monopodial (running bamboo) (Figure 2). The rhizome is situated at the base of the culm and consists of very short internodes.

**Culm:** is the main stem of the bamboo. It emerges from the buds on rhizome-nodes after they have enlarged for many months in the soil. The emerging culm shoots elongate rapidly to its full height before branching. The culm is the support structure for branches and leaves, and contains the main vascular system for the transport of water, nutrients and food.

**Node:** the joint between hollow segments of a culm, branch, or rhizome.

**Culm Sheath:** are the leaves that are attached at the node to provide protection at early stages of development (Dun, 1998; Liese, 1998).
5.2.2 Chemical and Anatomical Description:

Bamboo has a similar composition to wood. Bamboo consists of about 50-70% holocellulose, 30% pentosans and 20-25% lignin. However, it contains higher alkaline extractives, ash and silica content compared to wood (concentrations increase with age). Bamboos are tall grasses and, unlike trees, produce only primary shoot without any secondary growth (Figure 3).

Figure 3. Cross section of bamboo internode (Liese, 1998)

5.2.3 Properties:

In comparison to other engineering materials, it can be found that bamboo fibre has a similar tensile strength (650MPa) as steel (500-1000Mpa) and much higher flexibility (~50Gpa) compared to steel (~200Gpa). The bending strength of bamboo increases with age, and the culm is more flexible at the top of the bamboo than the bottom. The compressive strength of bamboo also increases with age, 3-5 year old bamboo being the strongest. Since bamboo is a biological material and is subjected to variability, the mechanical properties of bamboo vary within and between each species (Leake et al., 2010).

Bamboo is a very effective in preventing soil erosion. The roots of the plant remain in the soil during heavy rainfall, keeping the soil in place where it would otherwise be washed away (Dun, 1998).

Some species of bamboo have also been used as a traditional medicine (Ayurvedic medicine) in India for thousands of years. A translucent substance called Tabasheer, is obtained from the nodal joints of bamboo culms. It has a variety of benefits and is variously regarded as an antipyretic, antispasmodic, antiparalytic, restorative and aphrodisiac.
5.3 Artificial Regeneration:

5.3.1 By means of seeds:

Bamboo usually has a seeding cycle of about 30 years (Dun, 1998). The bamboo seed usually resembles the paddy grain, with a small horizontal clip in the middle. After gregarious flowering occurs, in most cases the whole plant dies. The bamboo seeds germinate generally within 5-10 days, however if they are stored in a tight container over silica gel, their viability is maintained for 1-3 years. Cost is approximately Rs.15 per kg (Arun, 2005).

Generally, seed is the best source of planting material for large-scale plantations, such as the one proposed for Devikulam. This is because seedlings are much easier to distribute than propagules (vegetative parts), and is also a much faster process (Dun, 1998; Kigom, 2007).

5.3.2 Vegetative propagation:

Another form of propagation utilizes propagules, such as rhizomes, culms and culm-branches. The culm is cut on either side of a node into small sized pieces. These pieces can be planted horizontally, slanting or erect. A favorable period to plant propagules is one to two months before the monsoon season, when the rhizomes possess active culm buds. Vegetative propagation is usually used for homesteads and small-scale plantations. It should not be used for large-scale plantations, as this method is slow, expensive, and requires an already established bamboo plantation (Dun, 1998; Kigom, 2007).

5.3.3 Bamboo tissue culture:

At the Department of Botany, University of Delhi, there is active research in the bamboo mass-propagation of tissue culture. Using the method of somatic embryogenesis, large-scale propagation of bamboos is possible at minimal cost and with the lowest labour input. Cloning bamboo plants with superior traits opens opportunities for achieving better quality bamboo crops. Although tissue culture for all bamboo species is not yet available commercially, somatic embryogenesis has been achieved for several species, namely, Dendrocalamus strictus, Bambusa arundinacea and Bambusa balcoa (Herleka, n.d.).

Growmore Biotech is currently meeting the national and international demands for bamboo tissue culture. They are partners with the NMBA (National Mission on Bamboo Applications). Located in Tamil Nadu, they have developed simple tissue culture that is farmer friendly and economical (NMBA, 2009).

CONTACT:
Dr. N. Barathi, Director, Growmore Biotech, 41 B, Sipcot Phase II, Hosur, Tamil nadu Tel: 04344-260564, 260565 Fax: 04344-260560 E-mail: growmore@vsnl.com
www.growmorebiotech.com
5.4 Plantation Plan:

5.4.1 Selection of Sites:

Much of the land in Devikulam was spoiled after the 2004 tsunami as salt-water contamination occurred in the region via a local backwater (EWB, 2011). As a result the quality of soil drastically decreased and has only recently begun to improve. It is therefore necessary to conduct a number of soil tests and plantation trials before selecting an appropriate area for the bamboo plantation site (Dun, 1998).

However, for the purposes of this report we propose that the bamboo be planted on the 3 - 4 acres of common, public land in Devikulam (Figure 4), plus any private land the Devikulam people wish to invest in this industry (EWB, 2011). If soil conditions in this area are appropriate for bamboo growth, then the whole community could benefit from the plantation. Any capital gained could be put back into expanding the project and continuing the education of the use of bamboo.

Figure 4. Map of Devikulam village (EWB, 2011)

5.4.2 Selection of Species:

Eight different bamboo species were investigated for the Devikulam plantation (Table 1). After close examination, Bambusa bambos and Dendrocalamus strictus were both found to have the appropriate characteristics needed for most of the constructions we had in mind. Both of these bamboos are common throughout India (Dun, 1998). Although both Bambusa bambos and Dendrocalamus strictus vary in traits such as height and strength, both species are more or less equally suited to the project (Table 2).
Table 2. Comparison between Bambusa bambos and Dendrocalamus strictus (Dun, 1998)

<table>
<thead>
<tr>
<th></th>
<th><strong>Bambusa Bambos</strong></th>
<th><strong>Dendrocalamus strictus</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution in India</td>
<td>15% of total bamboo area in India. Commonly found in homesteads of Southern India.</td>
<td>53% of total bamboo area in India. Uttar Pradesh, Madhya Pradesh, Orissa, and Western Ghats.</td>
</tr>
<tr>
<td>Soil Preference</td>
<td>Rich, moist, soil and grows along perennial rivers and valleys.</td>
<td>Well-drained, poor, coarse, grained and stony soils.</td>
</tr>
<tr>
<td>Life expectancy</td>
<td>24-32 years</td>
<td>32-47 years</td>
</tr>
<tr>
<td>Growth rate</td>
<td>30cm/day</td>
<td>11-16 cm/day</td>
</tr>
<tr>
<td>Height</td>
<td>25-30m</td>
<td>8-16m</td>
</tr>
<tr>
<td>Width</td>
<td>15-18 cm</td>
<td>2.5-8 cm</td>
</tr>
<tr>
<td>Strength (modulus of rupture)</td>
<td>35-39.3 N/mm²</td>
<td>118.4 N/mm²</td>
</tr>
<tr>
<td>Elasticity</td>
<td>1.5-4.4 kN/mm²</td>
<td>1.59 kN/mm²</td>
</tr>
<tr>
<td>Special uses</td>
<td>Shoots and seeds are edible. The leaves are used as fodder and medicine. Stabilizes eroded banks.</td>
<td>Young shoots are commonly used as food. Decoction of leaves and nodes and siliceous matter is used in the traditional medicine.</td>
</tr>
<tr>
<td>Yield</td>
<td>6 tonnes/ha</td>
<td>3 tonnes/ha</td>
</tr>
</tbody>
</table>
The ecological conditions of Devikulam must be considered to determine if one species may thrive better than the other. Bambusa bambos and Dendrocalamus strictus differ in soil preference. Bambusa bambos prefers rich, moist soil and grows along perennial rivers and valleys. Dendrocalamus strictus favors well-drained, poor, coarse, grained and stony soils (Dun, 1998)

Devikulam is subject to heavy rainfall during the monsoon season, however conditions are fairly arid throughout the rest of the year. The soil is only recently recovering from the effects of the 2004 tsunami so it can be presumed that the soil is marginal in terms of fertility. Based on this information, Dendrocalamus strictus would be the most appropriate species for a bamboo plantation in Devikulam (Figure 5). However, trials of both bamboos should be conducted first before any full-scale production is to go ahead.

**Figure 5. Dendrocalamus strictus**

### 5.5 Planting:

<table>
<thead>
<tr>
<th>Description</th>
<th>A very densely tufted bamboo, producing large dense clumps. Culms strong, hollow, up to 30 m tall, 15-18 cm in diameter; branches with thorns</th>
<th>A deciduous, densely tufted bamboo. Culms 8-16 m tall, 2.5-8 cm in diameter, thick walled. Sporadic flowering is seen in the first 5 years.</th>
</tr>
</thead>
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<th>A deciduous, densely tufted bamboo. Culms 8-16 m tall, 2.5-8 cm in diameter, thick walled. Sporadic flowering is seen in the first 5 years.</th>
</tr>
</thead>
</table>
5.5.1 Nursery:

Because of poor viability of seeds, once they are collected they should be sown in a nursery bed without delay. Seeds should be covered with a thin layer of soil and watered daily. Generally, this process is carried out in September/October (Kigom, 2007).

When seeds are 3 months old and are at least 3 cm in height, they must be transferred into polythene bags or hiko trays (more cost effective) of 150 gauge, and of size 20 cm x 10 cm, filled with well powdered soil and manure. The bags/ trays must be regularly watered for seedlings to be planted during July the next year (Dun, 1998).

5.5.2 Plantation site:

Pits of 30 cm cubed are dug at 5 m x 5 m spacing (Figure 5). The seeds need to be spaced far apart because an excessively dense plantation will lead to bamboo plants competing amongst themselves for light, space, soil moisture and nutrients (Dun, 1998).

Figure 5. Suggested bamboo seed spacing

Generally offsets, seedlings, culm cuttings etc. are planted by the beginning of the monsoon, during July. After planting, three weedings are done in the first year and two in the second year. Any casualties should be replaced at the beginning of next year’s monsoon. The area should be strictly protected in the first few years from grazing by providing protective fencing (Dun, 1998).

5.5.3 Fertilization:

The supply of nutrients at early stages of bamboo growth considerably increases growth and biomass production. Fertilization of plantation can increase the yield by more than 50%. Since Devikulam is mostly an agricultural village, manure could be collected from the cows that graze in agricultural farmyards and applied to the plantation annually in summer. This is a much more environmentally friendly and sustainable approach to fertilization than using a NPK artificial fertilizer (Dun, 1998).
5.5.4 Silvicultural tending:

Tending should be carried out regularly to remove twiners/climbers, weeds and broken and overhanging culms. Just before the rainy season, soil should be heaped around the developing culm each year (Dun, 1998).

5.5.5 Diseases:

There are a number of diseases that occur in bamboo nurseries, plantations and natural forests. The symptoms and control measures of a few diseases are outlined in table 3.

Table 3. Bamboo Diseases (Dun, 1998)

<table>
<thead>
<tr>
<th>Name</th>
<th>Image</th>
<th>Symptoms</th>
<th>Control measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf spots</td>
<td><img src="image1.png" alt="Image" /></td>
<td>Small, water-soaked, greyish black, linear to irregular lesions appear on mature leaves, and later coalesce and spread to the entire leaf laminas.</td>
<td>Application of fungicides, such as Difolatan (0.2% a.i.) or Fytolant (0.4% a.i.), is suggested for controlling the disease in severely affected young clump.</td>
</tr>
<tr>
<td>Root-rot</td>
<td><img src="image2.png" alt="Image" /></td>
<td>Yellow leaves, wilting, dieback and poor vigor. The most obvious sign of an infection are tan mushrooms at the base of the bamboo.</td>
<td>Root rot is incurable, but it can be managed. Avoid over watering or over fertilizing your bamboo. Use only the amount of water and fertilizer necessary for healthy plants.</td>
</tr>
</tbody>
</table>
Witches’ broom

Numerous highly shortened shoots develop at the nodes of mature bamboo culms. Silvicultural measures, such as pruning and removal of infected minor branches. No chemical treatment is available.

Bamboo blight

Large, water-soaked, irregular lesions with greyish green centers and greyish white margins occur in leaves. No control measure has been suggested. However, pruning the diseased branches from affected clumps, and cleaning and burning the debris will reduce the damage.

5.5.6 Insect Pests:
Bamboos are also susceptible to attack from a number of insect pests. Green bamboos are the most vulnerable as they have not developed a protective outer woody layer. Table 4. Outlines the symptoms and control measures for three common insect pests.

Table 4. Bamboo Insect Pests (Dun, 1998)

<table>
<thead>
<tr>
<th>Name</th>
<th>Image</th>
<th>Symptoms</th>
<th>Control measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defoliators</td>
<td></td>
<td>Holes in leaves and distortion of foliage.</td>
<td>Foliar spray of dimilin 25 WP (0.002%)/Cypermethrin (0.002%)/Folithion (0.2%) in water.</td>
</tr>
</tbody>
</table>
### Borers

![Borer Image]

- **Dying of shoots and holes in the culms.**
- **Injecting dimethoate 30 ec (0.01%)/Monocrotophos 36 ec (0.2%) in water.**

### Sap suckers

![Sap Sucker Image]

- **Dying of young shoots.** Shoots are covered with minute insects in large numbers.
- **Spray of dimethoate 30 ec (0.02%)/Monocrotophos 36 ec (0.02%).**

---

### 5.6 Harvesting:

The cutting of bamboo is a simple process with little equipment required. Bamboo can be easily cut with a saw, machete or even pruning shears. It should be cut just above the first or second node above ground level so that there is no receptacle in which rainwater can collect. Stagnant water may cause rot and could weaken the bamboo plant system (Guadua Bamboo, 2011). One of the first things to consider when cutting the bamboo is the length of the stalk required. If the width is 1 inch or less it can be cut using sharp hand pruners. However, it is vital the pruners are sharp; otherwise the end of the bamboo may crush and splinter. If the width is thicker, a sharp saw will make harvesting quick. Once the bamboo stalk has been felled, it can be cut into smaller pieces. The bamboo is positioned on a hard surface with the end that needs to be cut just off the edge. If it is extra-long, make sure the other end is also supported to reduce the risk of bending and cracking (Kigom, 2007).
5.7 Summary of the Warehouse:
The construction of a warehouse would create a great deal of potential to value add on the harvested bamboo. By value adding, we are making the most of the resource, creating more income and jobs for the people of Devikulam with potential benefits far exceeding that of income on both the workers, their families and future generations. The warehouse is designed to provide areas of treatment and drying as this is necessary for almost any product you wish to produce with this resource. The rest of the warehouse is designed to be very flexible in its application. It allows for the empowerment of the people of Devikulam to make a choice on what they would like to do and produce with their opportunity presented to them out of different options available to them. In this way, we will not be imposing a solution but rather granting the community an opportunity to take control of their own futures by playing a role in deciding for themselves what they would like to create in the village. This increases the chance of the proposal being accepted and adapted to people’s existing lifestyle and hence will be successful by acting to improve the quality of their lives. This bottom-up approach is likely to be more sustainable and be integrated in the community. The warehouse will be made out of mostly local, ecological materials that are mindful of the climatic conditions of the region and also supporting local bamboo community projects that are similar to what we are trying to create. It uses the innovative inventions that have been discovered in India and across the world to make it as environmentally sound and cost efficient as possible. The warehouse not only works as an income generator, but also a place that can be transformed into a community centre due to its large size and flexibility. This can create cohesion within the community, whilst the partly outdoor section acts as an area for women empowerment by providing job opportunities, involvement and a place where the village can interact and socialise.

Presented below are different angles of the warehouse created on the program Google Sketch.
**Components**

**Roofing**

For roofing, we propose to use the new innovation of corrugated bamboo roofing sheets (CBRS). There are a series of projects around India currently implemented in impoverished rural areas of India for the production of CBRS as a means of income generation poverty alleviation and employment (INBAR, 2006). They are a fantastic alternative to iron, plastic or zinc roofing sheets for a number of reasons:

- They are produced from natural materials
- They are durable and resilient to adverse weather conditions
- They are resistant to pest attack
- Can be produced in a range of standard sizes
- They are cooler in the sun than metal sheets (this is important because the people of Devikulam complained of undesirable heat under the corrugated iron government housing)
- They support relatively local rural communities of India with employment and income – especially women
- They are better for the environment due to the use of sustainable bamboo resources

CBRS are produced by pressing firmly together woven bamboo mats that have been saturated with an adhesive resin. The corrugations are formed by pressing them between corrugated pressing plates in the pressing machine. A unit producing half a million square metres of roofing sheet per year will create employment for about 200 people, most of whom will be required for the production of bamboo mats who are usually women (INBAR, 2006).

**Flooring**

We recommend using concrete as the flooring of the warehouse due to the fact that this medium would be safer for warehouse operations, does not allow moisture penetration, allows for easy cleaning and long lasting. However, the downside of concrete flooring is that they tend to require copious amounts of energy and water to produce. Luckily there are low ways to have concrete flooring without effecting the environment so much. Recycled concrete flooring uses substitutes out of various industrial waste materials which allows for the recycling of these materials and a reduction of the carbon dioxide output. High-Volume Fly Ash is an industrial by-product of coal burning power plants that are produced in gigantic quantities in countries such as India and China due to the coal burning producing more than 100 million tones of fly ash waste annually. For countries like China and India, this technology can play an important role in meeting the huge demand for infrastructure in a sustainable manner”. This seems to be ideal for the flooring of Devikulam for this reason. The concrete that is primarily made with ashcrete (a concrete substitute made with over 97% high volume fly ash) would be ideal for mitigating the environmental impacts of the concrete (National Concrete Pavement Technology Centre, 2010).

This concrete flooring would cover all areas of the warehouse. For the outdoor multipurpose section however, we propose to cover the concrete with a layer of handmade bamboo mat which
would insulate and make the ground more comfortable to allow for sitting if weaving and community gatherings were to take place there.

**Walls**

For an environmentally friendly, locally sourced, cheap material for the constructing the walls, we have found that compressed earth blocks (CEB) would be ideal for the warehouse. They have a number of advantages including producing uniform building component sizes, use of locally-available materials, reduction of transportation, minimal wastage, insulating against heat; keeping warehouse cool, fast construction, and ability of integration with the corrugated bamboo roofing sheets.

A range of machines are available to produce these bricks. For our project we chose to use the hand-operated TEK press from the University of Science and Technology in Ghana if it is available. The design does not require electricity, is simple and inexpensive but efficient. The design requires less labour. This process does not require much skill to conduct. The simplicity of the operations makes the machine especially suited for unskilled labour, although some care is needed to ensure proper filling of the mould. The TEK produces a brick size of 30 x 23cm x 15cm but the thickness of the brick can be reduced by putting a board in the bottom of the mould (Nelson, n.d.).

The soils need to be tested to see if they are compatible with making a functional CEB, however it is good to note that consulting with the people of Devikulam could be beneficial because they may have experience with how the soil would function when constructing seeing as most of their houses are made out of mud.(SHEE)

**Materials:**

- Soil with a minimum of 10% clay
- Cement 5-10% depending on requirement

**Main equipment**

- Pan mixer
- Trolleys
- Manual block forming machine

**Power:**

- KW:11.25(for Mixer
- Three phase
- Voltage: 440V, 50Hz

**Man power**

- Skilled, 1
- Unskilled, 8

**Projected cost**
• Price


• No. of blocks per cycle/output rate
  1 /50 blocks per hour

• Labour force required (incl. excavation and mixing)
  10 men

(University of Science and Technology Kamasi 1988)

**Support beams and frame**

Support beams would be made out of treated bamboo sourced from nearby villages. This would be environmentally friendly option, but also very functional because bamboo is very strong sustainable resource and is even earthquake resistant. This would also be another economical material which can support local rural communities. In addition, the villagers are likely to know how to construct with bamboo, if not, it can be simply taught.

**Lighting**

There has been a magnificent innovation in the Philippines using recycled materials with the utilisation of natural light to provide light good quality light, indoors and free from the sun. The simple design uses only a small number of components:
- 1.5/2L soda bottle
- small square of corrugated iron sheet
- Rubber sealant
- a capful of Bleach
- Filtered Water
By Combining one capful of bleach in the bottle (to stop the water having algae growth) and clean water, then cutting a hole in the corrugated iron square and fitting it around the bottle then cutting a similar hole in the bamboo roof and inserting it the bottle; an equivalent of a 55watts light bulb is created. This lasts for approximately 5 years and provides a very cheap alternative to the electric light bulb and is very environmentally friendly due to reusing old resources and the lack of need to use electricity. The water, bleaches, and corrugated iron and rubber sealing costs approximately $1US (Isang Litrong Liwanag, 2011).

6 Manufacturing Plan

6.1 Manufacturing Overview
The warehouse will be made with a combination of volunteers, professionals, together with local involvement so they feel directly responsible for the construction of the warehouse and would be proud of it to allow for the desire to make the project work. Also this may utilise skills the people in Devikulam already possess from using their local materials such as bamboo and mud for the construction of their houses for previous generations. The walls can be made by the locals and volunteers manually, and the roof can also be installed without a professional. The concrete flooring on the other hand would need professional assistance to construct, and possibly the bamboo support beams in the concrete.

6.1.1 Bill of Materials
- Borax
- Boric acid
- Purified water
- Soda bottle
- Rubber sealant
- Bleach
- Corrugated iron sheet
- Corrugated bamboo roofing sheet
- Bamboo poles
- Bamboo mats
- Concrete
- Ashcrete
- Local soil
- Trolleys
- Pan mixer
- Manual block forming machine
6.2 Treatment

To increase the longevity and the value of the bamboo, we propose to dry and treat it in the warehouse.

The Treatment area consists of two concrete containers of dimensions of 4 x 10 x 1.5m. The harvested bamboo poles get carried to this area on the side of the building. They are prepared by being cut into 3.5m fragments by a machete. The tubs are prepared with the preservative solution of borax acid and borax solution. Then the bamboo poles are simply dipped in the water soluble disodium octaborate for several hours. The Boron salts are then at a concentration of 5-10% which is enough to protect against fungi, insects and termites attack. There are several preservative treatments procedures that can be used on the bamboo. The choice of employing the use of boric acid and borax as the medium was due to the ease of use and the low toxicity of the chemical making the disposal and application not safer to both the environment and the workers.

This process is currently functioning in a poverty alleviation/ income generation project in a small rural town in the Tamenglong district, Manipur state, India by creating a small-scale enterprise from bamboo preservation. It produces 12,000 poles per year; each 48 hour treatment cycle treats approximately 100 poles of 7-10cm wide and 3.5m in length. The process is recommended for bamboo culms that would not be exposed to water or excessive moisture.

Process

Step 1. Boric acid and borax are mixed in 1:1.4 ratio, made into a solution with water and poured into the preservation tank.

Step 2. The bamboo poles to be treated are cross-cut to approx 3.5m in length.

Step 3. Using a drill, small holes are drilled on the internodal parts of the poles for better preservative penetration.
Step 4. Bamboo poles are placed inside the tank for 48 hours. One tank will hold 30-40 poles of a diameter of 7-10cm.

Step 6. The treated poles are removed from the tank and kept in slanted against the back wall for quick drying. The concrete flooring prevents contact with ground which makes the bamboo at risk of mould or insect infestation.

Step 7. Preservative solution is recharged after four cycles by adding water and the chemicals (INBAR, n.d.)

6.3 Drying

To Dry the bamboo, it is recommended to air dry it, simply because this is more environmentally and economically viable option which is simple and compatible to the Devikulam Industry. Air drying takes 6-12 weeks, depending on the initial moisture content and wall thickness. Bamboo drying vertically will dry faster than horizontal stacking (INBAR, n.d.) Therefore to dry the bamboo, it would be as simple as leaning it against the back wall of the treatment area until dry. This will occur following the treatment. It is important to note that the culms must be away from direct soil contact to prevent fungal or insect attacks and to avoid the humidity of the soil affecting the drying process. The bamboo must be kept away from direct sunlight in a well ventilated area. Taking this into account, the warehouse during and treatment are has been designed to have concrete flooring, shelter and be open without walls.
7 Manufacturing Plan

7.1 Manufacturing Overview
The warehouse will be made with a combination of foreign volunteers and professionals, along with local labour and involvement, so they feel directly responsible for the construction of the warehouse and would be more willing to make the project work. Also this may utilise skills the people in Devikulam already posses from using their local materials such as mud for the construction of their houses. The walls can be made by the locals and volunteers manually, and the roof can also be installed without a professional. The concrete flooring on the other hand would need professional assistance to construct, and possibly the bamboo support beams in the concrete.

7.1.1 Part Drawings
7.1.2 Bill of Materials

- Borax
- Boric acid
- Purified water
- Soda bottle
- Rubber sealant
- Bleach
- Corrugated iron sheet
- Corrugated bamboo roofing sheet
- Bamboo poles
- Bamboo mats
- Concrete
- Local soil
- Trolleys
- Pan mixer
- Manual block forming machine

8 Marketing

8.1 Main problems inhibiting Bamboo market

- Insufficient supply of Bamboo for entrepreneurial use
- Market Linkage - There is a poor relationship between buyers and sellers in the Bamboo market
- Lack of awareness about industry – people are not educated on the benefits and industrial uses of Bamboo, therefore they do not invest time/money into harvesting/promoting it
- Laws/protocol- there are certain restrictions in place making it difficult to harvest bamboo
• Poor post harvest treatment + poor training- improper harvesting and growing methods have led to a lower yield of bamboo, thus decreasing the supply of bamboo needed to meet demand.
• Competition from Chinese markets

8.2 China’s Success
Globally, China has been the most successful in terms of industrializing the use of bamboo. By forming a chain of bamboo plantations that aid in the production of furniture, flooring, charcoal and fresh bamboo shoots, China has been able to penetrate both the domestic and export Bamboo markets thus increasing it’s productivity by over 10 times since 1970.

8.3 How to tackle these problems/ possible solutions
China’s success seems to stem from two fundamental aspects:
1: It is evident they understand the value of bamboo as they have penetrated a number of different markets through the use of bamboo.
2: They have successfully created a link between buyers and sellers both domestically and internationally.

8.4 Education
When implementing the concept of creating a bamboo industry within Devikulam, it is important to educate the people on the proper and most efficient methods of harvesting Bamboo, as well as post harvesting treatments, so as to produce the maximum yield possible, thus resulting in the maximum returns for the village. It could also be beneficial to educate the village on the profit and employment possibilities that could be available to them if they were to create a bamboo industry.

“A public interest awareness campaign was felt to be essential for promoting the sector by most of the industry representatives throughout the country. The sector cannot thrive by making handicraft items like baskets anymore. There has to be a movement towards lifestyle products and utility products”

In terms of Devikulam, if we were to establish a bamboo industry, effective promotion could be carried out through the following methods:
Through EWB’s reputation and resources. A series of campaigns could be launched through EWB to spread awareness of the importance of bamboo and the project being carried around in Devikulam. Hopefully this can attract potential buyers/investors to the project and create some international awareness.
Appeal to government involvement through campaign.

8.5 Markets
It is important to identify which markets within the bamboo industry would prove to be most profitable for Devikulam. International markets should also be considered as one of the reasons China is so successful; they export their bamboo internationally.

“Over 2.2 billion people the world over are dependent on bamboo and its related industries for income, food, and housing.” (Marsh, 2007).
This figure sheds some light on the scope of the Bamboo market and the demand for bamboo related goods that Deviukulam has the potential to exploit. Research has shown there is a particularly high demand for bamboo is Asia; in particular Japan, Singapore, Malaysia, Taiwan, Korea and other countries.

In terms of the Domestic market within India, the following table displays the consumption patterns of Bamboo within in India:

<table>
<thead>
<tr>
<th>Uses</th>
<th>Percentage Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulp</td>
<td>35 %</td>
</tr>
<tr>
<td>Housing</td>
<td>20 %</td>
</tr>
<tr>
<td>Non-residential</td>
<td>5%</td>
</tr>
<tr>
<td>Rural uses</td>
<td>20 %</td>
</tr>
<tr>
<td>Fuel (non – industrial)</td>
<td>8.5 %</td>
</tr>
<tr>
<td>Packing, including basket</td>
<td>5%</td>
</tr>
<tr>
<td>Wood based industries and Transport</td>
<td>2.5 %</td>
</tr>
<tr>
<td>Furniture</td>
<td>1%</td>
</tr>
</tbody>
</table>

Therefore, as far as domestic prospects go, preparing the bamboo for pulp/housing and rural uses would provide Devikulam with the greatest returns.

In terms of the global market that Devikulam could exploit, the first table shows each different bamboo industry’s market share in US$ in 2007. The second column displays the predicted market share by 2017.

<table>
<thead>
<tr>
<th>Industry</th>
<th>World Market share (US $m 2007)</th>
<th>World Market share (US$ m 2017)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handicrafts</td>
<td>3000</td>
<td>4200</td>
</tr>
<tr>
<td>Bamboo shoots</td>
<td>1500</td>
<td>1700</td>
</tr>
<tr>
<td>wood furniture</td>
<td>1100</td>
<td>5600</td>
</tr>
<tr>
<td>wood flooring</td>
<td>100</td>
<td>1200</td>
</tr>
<tr>
<td>wood panels</td>
<td>200</td>
<td>2200</td>
</tr>
<tr>
<td>blinds</td>
<td>500</td>
<td>1200</td>
</tr>
<tr>
<td>chopsticks</td>
<td>300</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>2010</td>
<td>2011</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>charcoal</td>
<td>100</td>
<td>130</td>
</tr>
<tr>
<td>activated carbon</td>
<td>20</td>
<td>170</td>
</tr>
<tr>
<td><strong>total</strong></td>
<td><strong>6825</strong></td>
<td><strong>16830</strong></td>
</tr>
</tbody>
</table>

(Marsh, 2007)

This table displays Handicrafts and bamboo shoots as generating the most revenue, however in 2017 there is a predicted rise in the demand for wood furniture and wood panels that Devikulam could exploit.

There are 3 main markets for Bamboo: Traditional, non-traditional and emerging. Currently, the most profitable market is the traditional market that produces goods such as bamboo shoots and handicrafts. However, as the table displays, there are large opportunities for growth in the emerging market that produces Bamboo flooring and housing related items or “wood product substitute-based markets.” (Marsh, 2007).

It is these markets that Devikulam should aim to try and penetrate as they will have a lower degree of competition within them considering they are ‘un-tapped’ markets in comparison to the traditional ones.

In this study conducted by Oxfam, they use “the term “pro-poor financial impact” to describe this local component of total revenue that is captured by poor communities.” This study shows that the segments with the highest ‘Pro poor profits” are the “ premium processing industries”, e.g Flooring/furniture. While this does require high quality bamboo, this segment results in double the rate of economic growth in comparison to medium processing industries and 5 times the rate of growth in comparison to low level industries.

Therefore, if Devikulam focused on harvesting and treating premium quality Bamboo, there are possible export opportunities to premium processing industries.

### 9 Implementation Plan

#### 9.1 Implementation Overview

Because the warehouse is not yet constructed, we obviously cannot use our own treated bamboo for the construction. Therefore, all materials must be purchased from neighbouring villages. These will be transported to Devikulam by either car or van depending on what it is that is needed to be transported. The site will be allocated and over the course of approximately a month, the warehouse would be built in collaboration with the knowledge and labour of the locals, volunteers and professionals. Before this however, there needs to be an education program that is instigated to teach the locals the benefits of a bamboo industry in their village and what the purpose and usage of the warehouse is. Once the warehouse is constructed however, further educational programs would be necessary to initiate on how to use the warehouse and further education on
what the industry would do in Devikulam and how to run it. This can be done within the warehouse for added significance and it can also be used for demonstrations.

**9.1.1 Additional Uses**

In order for development to be sustainable, it should be a continual process that does not cease immediately after the project has been implemented, so we explored briefly Devikulam’s options once the bamboo industry had been established and starts being profitable.

Bamboo is an extremely useful, multi-purpose resource, largely dependant on its age.

Bamboo harvested after less than 30 days can be used as a source of food; bamboo 6-9 months of age is a good material for basket weaving; and bamboo 3-6 years old is ideal for building construction and floorboards. In addition, bamboo can be used to make clothes, furniture and bicycle frames.

As outlined in Option 2, the ‘Bamboo Bicycle’ project was a viable solution to tackling a number of Devikulam’s developmental issues, including transportation, industry and education.

**9.2 Community Engagement:**

**9.2.1 Community of Devikulam:**

The community of Devikulam has a Hindu religion. The community is deeply divided between social classes or “Castes”. People of different castes do not normally associate with each other and there is a mutual acceptance of this fact amongst the villagers. (EWB, 2011) Another challenge to overcome is the perception of bamboo as a ‘poor man’s timber’. The culture of India tends to perceive bamboo as poor people housing. Adams (n.d.) states that stone is used to build houses for highest castes, wood uses to build house for the middle castes but poor people or the lowest caste will use bamboo.

**9.2.2 Community Engagement Research**

Despite the most brilliant technology or innovative idea, these could have no benefit to a community if they do not embrace it and fully engage with the project. To have a successful project, you must first of all have a good product or concept to implement, however secondly you, and possibly most importantly is the ways in which you implement the project. For example, it will be no good in our project if we were to come in, build a warehouse and give them bamboo plants, tell them to go for it, and then leave. This would end in total failure. This is why, drawing inspiration from the Jamkhed Comprehensive Rural Health Project and personal experiences with working in a Hindu community, we have devised a suitable plan that will complement our project.

The Jamkhed Comprehensive Rural Health Project (CRHP) was founded in 1970 by Drs. Raj and Mabelle Arole and has been working with the rural poor and marginalised for more than 40 years. It has brought health care to the poorest of the poor. CRHP is now an organisation that empowers people to eliminate injustices through integrated efforts in health and development. CRHP works by mobilising and building the capacity of communities to achieve access to comprehensive development and freedom from stigma, poverty and disease. There is one aspect of the project we will like to draw most inspiration from, and that is the development of a Farmer’s Club and an agricultural training land plot (Comprehensive Rural Health Project, 2011).
In order to enhance the learning of farmers in the Jamkhed area, in 1995 CRHP decided to develop its own farm as a demonstration and training centre. With an agricultural expert on staff the farm has been operated by AIDS, leprosy, and TB patients in need of support and rehabilitation (Comprehensive Rural Health Project, 2011).

9.2.3 Community Engagement Plan
A key factor in the success of the CRHP project as the fact they worked with the community. Not only that, CRHP was successful in breaking down the caste barriers, making for a more cohesive, productive community. Education is also the key. We will teach the community the amazing benefits of bamboo, which in turn will allow them to make the choices. We would suggest forming a strong bond with the local government, but also have a member from within the community to liaise with and to create a bridge between us and the community. This person will be invaluable. Their role will not only to liaise with us, but act as the ‘go-to’ person for people of the community and the higher level of government. Ideally, in the long term, this project can be run with minimal to no outside input; therefore there must be some sort of structure within the community. For example, in the future the marketing, business aspect of the bamboo will be all locally run. It will not be us who is teaching and working in the bamboo crops, but the members of the community. Our role is to help facilitate and guide the project at the beginning.

Step 1. Before even stepping foot in Devikulam territory, communication must be made with the local government of the Devikulam Area. They must approve the project and be willing to be involved.

Step 2. At this point, it is up to the government and us to work together in engaging the community and introduce the idea. We will put together ‘bamboo packages’ to be distributed amongst the community. These packages will contain all the basic essential information about bamboo and the benefits. We can educate a few members of the community or government in benefits of bamboo, why sustainability important, why bamboo would be great in Devikulam, essentially all the Why’s. It will be like a trickle down system of knowledge but also generating a community sense of responsibility.

We will have training days for all teachers. In these training days we will introduce new methods of engaging with students, but also just like the other members we will teach the Why’s. Through past experiences with small village schools, there are few stimulating and engaging activities teachers employ to educate the children. Activities can include craft lessons using bamboo, learning songs about the environment and possibly even make bamboo instruments. Just small fun activities that introduce and excite the minds of the children. After all, it is the children of today that lead tomorrow.

We will run community programs to begin to break down the caste barriers. There will be activities to encourage intermingling. Taking an example from a CHRP, there was a training weekend for women. When the woman slept they were given not one single rug, but each individual rug had been sewn together so they were forced to sleep all under the same rug.
Step 3. The growing of Bamboo. This is where we draw more inspiration from The Jamkhed training farm. We will be there at the start to teach the members of the community how to cultivate and harvest their own bamboo. However, one of the biggest successes of the training farm was how they turned the ‘untouchables’ into valued members of the community. The primary people they involved within their farm were the untouchables, or the Most Backward Caste. It is these households we would like to get involved within the farming aspect of bamboo. We would also like to involve the families involved within the prawn industry, leading them towards a more sustainable industry.

Step 4. Building of Warehouse. This will be an essentially voluntary process, with only a few paid workers to ensure accuracy and the completion of the building. There are a number of reasons for this. Firstly it is cost effective. Secondly not only does it create a great sense of community, but the more the time community itself invests and engages in the project, the greater the sense of ownership they will have, therefore in turn responsibility.

Step 5. Once the Warehouse is complete, new training days will be held within the warehouse. They will be practical and hands on, developing skills that would have been taught theoretically on the farm, like drying bamboo.

Step 6. Initially we will help facilitate the exporting of bamboo, and help set up connections within a wider geography, however these are skills we will teach.

10 Discussion
10.1 Strengths and Weaknesses

<table>
<thead>
<tr>
<th>EXTERNAL FACTORS</th>
<th>Opportunities:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Opportunity to get subsidy from government. There is currently government subsidy for Bamboo industry</td>
</tr>
<tr>
<td></td>
<td>Increase in projected world market for bamboo industry. So, there is potential market for export to other countries.</td>
</tr>
<tr>
<td></td>
<td>Opportunities to produce more range of bamboo products once it the industry is growing. All the bamboo parts are actually useful so it is good if Devikulam people could utilize all the material and minimize the waste.</td>
</tr>
</tbody>
</table>

<p>|                  | Threats: |
|                  | Government regulation to set up a new industry might opposed bamboo project plan |
|                  | Threat from competitors from other bamboo industry might have higher capital |</p>
<table>
<thead>
<tr>
<th>INTERNAL FACTORS</th>
<th>Strength:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bamboo is environmental friendly material so it is sustainable option</td>
</tr>
<tr>
<td></td>
<td>Bamboo is strong and flexible so it could be use in the construction and furniture production</td>
</tr>
<tr>
<td></td>
<td>Bamboo is low cost material</td>
</tr>
<tr>
<td></td>
<td>Bamboo is one of the fastest growing plants. It only takes around 3-5 years before bamboo could be use in production</td>
</tr>
<tr>
<td></td>
<td>Bamboo plantation could actually help water desalination. It helps to filter salt from sea water</td>
</tr>
<tr>
<td></td>
<td>Warehouse could be use for community building where people gather together and involve in the bamboo production</td>
</tr>
<tr>
<td></td>
<td>Create employment opportunities and generate more revenues. Compared to the current agriculture sector that Devikulam has, commercialization of bamboo products is more profitable</td>
</tr>
<tr>
<td>Weakness:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Castes issues leads to perception that bamboo used by low caste people</td>
</tr>
<tr>
<td></td>
<td>If it is not treated well, bamboo could be attack by insect</td>
</tr>
<tr>
<td></td>
<td>Bamboo surface is difficult to paint so there must be special treatment if bamboo products want to get painted</td>
</tr>
<tr>
<td></td>
<td>Other materials in production might not be sustainable so the products only sustainable through a certain extent</td>
</tr>
<tr>
<td></td>
<td>Waste management of the production and from the warehouse building</td>
</tr>
<tr>
<td></td>
<td>The soil in Devikulam is only recently recovering from the effects of 2004 Tsunami</td>
</tr>
</tbody>
</table>
10.2 Health and Safety

Mechanical hazards:
Type of agent:
• Struck by objects
• Confined space
• Slips and trips
• Falling on pointed objects

Type of damage:
• Collisions
• Crushing
• Cutting
• Stabbing and puncture
• Abrasion

Other physical hazards:
• Heat stress (hyperthermia)
• Dehydration

Chemical hazards:
• Boric Acid - requires safety glasses when handled.
• Glue

Biological hazards:
• Bacteria
• Virus
• Fungi

Psychosocial issues:
• Work related stress
• Bullying
• Sexual harassment

Fire prevention

10.3 Next Steps
There is so much scope for great opportunities with the bamboo project. The next stage is to start making money from the bamboo plantation, and the endless possibilities of the products produced from the bamboo. As already discussed, bamboo is an incredibly versatile and sustainable material, that has a huge range of possible markets the village can exploit. Once members of the village has successfully grown and treated the bamboo, other members can become involved in different ways.

There must be different members of the village associated in different aspects of the bamboo. For example there must be people who manage the business side, such as establishing market routes outside of Devikulam. There must be the artisans who make the actual products.
There must be people involved with the transport of products. There are numerous employment opportunities.

Here are the recommended steps to take:
1. Establish potential buyers of the bamboo.
2. Prepare bamboo to requirements of the buyer.
3. Devise methods of transportation.
4. Export of material.

However there are not just monetary benefits to the products of the bamboo plantation. Here is one example of the benefits of a bamboo product, bamboo bikes. The bamboo bike has numerous benefits to the workings of the community. One of the problems the villagers faced was the lack of good transport to neighbouring village, Nadukuppam. It made getting to school difficult for the children, as well as unpleasant due to open defecation. If there were bikes, the standard of education would improve due to higher attendance as well as reducing the need to go to the toilet on the side of the road.

The bamboo plantation and warehouse has many exciting results, and the village can reap many of the rewards.

### 11 Evaluation Plan

#### 11.1 Generate local employment for a range of people, thus improving the yearly income per capita in the Devikulam community.

By establishing a bamboo industry, jobs will be created throughout the process. In the plantation jobs would be created in propagation and harvest of the bamboo. In addition, the value adding to the bamboo creates additional jobs during the harvesting and treatment of the bamboo. The more that's is done with the bamboo, the more jobs are created in this industry, so it has potential for increasing the impact into the future.

#### 11.2 Utilize the skills that the people in the community have already developed.

The people of Devikulam are largely employed in the agricultural industry. Therefore, these people have already gained knowledge through past experience and so already posses many necessary skills that are required in planting, growing and harvesting.

#### 11.3 Have a low initial and maintenance cost.

With the help of the subsidies provided by the government for bamboo industries together with using freely available, locally sourced resources and land, the initial cost of the project will be minimal. The use of the cheapest materials available that are long lasting such as the light bulbs, compressed mud blocks, concrete and treated bamboo results in little maintenance. If maintenance is required, this can be done by the local people of Devikulam for little cost and labor. In addition the use of bamboo and its self-regenerating properties results in the lack of need to replant the bamboo after harvest; in
a way it maintains itself. The bamboo species are hardy and are capable of growing in selected conditions with little human intervention. This ensures the longevity of the bamboo industry for low maintenance cost.

11.4 Be environmentally friendly by ensuring there is no contamination of Devikulam’s environment, and without exploiting their current resources.

The warehouse uses many innovative, environmentally friendly resources in its construction and maintenance. The use of solar powered soda bottle lights in the warehouse recycles materials and does not require electricity in its upkeep. The bamboo roof uses local resources and has a higher lifespan and is more environmentally friendly than corrugated iron. The walls of compressed blocks are made out of locally sourced soil, which requires no electricity to produce. Additionally, the concrete flooring utilizes the waste product of coal power stations in India (fly ash). The boric acid is the most environmentally friendly option available for treating bamboo and can be disposed with little effect on the environment, if done properly (although it can increase the salinity of the soil). The bamboo itself is not damaging to the environment, and on top of that, is a fantastic carbon sink. Bamboo can also reduce erosion of the slopes, as its roots hold the soil together.

11.5 Ensure the sustainability of the industry.

Bamboo is a self-regenerating plant, that requires little human maintenance or costly capital, and so the growing of it is a sustainable practice. In the time of increasing climate concerns and resource scarcity, the market for bamboo as a renewable, eco-friendly resource is only going to continue to grow. This change in mindset and direction to sustainable resources such as bamboo supports the longevity of the bamboo industry.

12 Evaluation Supporting Documents

12.1 Cost analysis

12.1.1 Initial cost of planting
Cost of site preparation/cleaning land $29.32 AUD/ha
Cost of digging pits for seeds $15.64 AUD/ha
Nursery Cost (raising plants) $14.66 AUD/ha
Weeding/cleaning $1.95 AUD/ha
Watering/fertilizers $4.89 AUD/ha
In the second years, beating up of failures $2.93 AUD/ha

Considering we’re using 3-4 acres of land, that equates to approximately 1.6 Hectares. This means an approximation of the total planting cost for this amount of land is: $110.24
12.1.2 Cost of Shed and Treatment
(The following costs may differ slightly based on the difference in the shed designs. We estimate our treatment tanks will be cheaper as we plan to use concrete which will not need to be replaced)
Erecting the shed: $134.54 AUD
Treatment tanks: $ 674.42 AUD
Main equipment $5,500 AUD
Essential spare parts and tools- $200 AUD
Civil construction- $4,000 AUD
Total estimated cost of shed + treatment: $10,508.96

12.1.3 Benefit analysis
Annually, using the above costs, it is estimated that 12000 poles are able to be produced per year. Assuming that all these poles are sold at the local market price of 9 cents per pole, per year, the village is estimated to make $1037.88 AUD. This means that in just over 10 years the village will break even and start earning profit. However this study is based on selling bamboo domestically in Indian markets. If Devikulam were to export their bamboo, they would be able to charge a higher price thus earning more money per year and decreasing the amount of time needed to break even.

<table>
<thead>
<tr>
<th>Category</th>
<th>Value US$</th>
</tr>
</thead>
<tbody>
<tr>
<td>handicrafts</td>
<td>2415</td>
</tr>
<tr>
<td>kitchen articles</td>
<td>23796</td>
</tr>
<tr>
<td>basketry</td>
<td>70645</td>
</tr>
<tr>
<td>decoration</td>
<td>31221</td>
</tr>
<tr>
<td>garden</td>
<td>27000</td>
</tr>
<tr>
<td>raw material</td>
<td>15654</td>
</tr>
<tr>
<td><strong>Furniture</strong></td>
<td>20081</td>
</tr>
<tr>
<td>furniture with woven parts</td>
<td>6452</td>
</tr>
<tr>
<td>cane based furniture</td>
<td>4778</td>
</tr>
<tr>
<td>with other materials</td>
<td>3289</td>
</tr>
<tr>
<td>tables</td>
<td>1794</td>
</tr>
<tr>
<td>chairs</td>
<td>1613</td>
</tr>
<tr>
<td>crates</td>
<td>1352</td>
</tr>
<tr>
<td>shelves</td>
<td>473</td>
</tr>
<tr>
<td>bedroom articles</td>
<td>185</td>
</tr>
<tr>
<td><strong>Flooring</strong></td>
<td>70,453</td>
</tr>
<tr>
<td>flooring as such</td>
<td>64600</td>
</tr>
<tr>
<td>accessories</td>
<td>2952</td>
</tr>
<tr>
<td>without finishing</td>
<td>1563</td>
</tr>
<tr>
<td>finished</td>
<td>544</td>
</tr>
<tr>
<td>parquet</td>
<td>455</td>
</tr>
<tr>
<td>panels</td>
<td>154</td>
</tr>
<tr>
<td>veneer</td>
<td>104</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>262265</td>
</tr>
</tbody>
</table>
(Lugt, 2008)
As the table indicated, the value of bamboo in the US is substantially higher than the value in India, therefore creating the potential for Devikulam to break even faster if they were to consider exporting bamboo. The price of the raw material alone is valued at $15,654 US which equates to $14,953 AUS. This indicates that if Devikulam were to exploit the US market by exporting the raw bamboo they have grown, harvested and treated; they would be able to break even and cover their setup costs within a year. Furthermore, as mentioned in the marketing section of 3.2: the projected value of bamboo is expected to increase significantly, therefore, it is highly likely that the value of bamboo in the US market is higher than the above figures collected from 2004.
13 References List


Herleka, D. (n.d.). Bamboo Flowering & Tissue Culture. Retrieved September 27, 2011, from www.vigyanprasar.gov.in/Radioserials/Bamboo%2520Flowering%2520%26%2520Tissue%2520Culture.pdf+Herleka.+Bamboo+Flowering+%26+Tissue+Culture.&hl=en&gl=au&pid=bl&srcid=ADGEESjlWkt3c5RmBh4mHZM-rCdYoWFGl4tcyoUne8wvaitUYnbyalYz_AWNvYSFrIO2nGZb74092In_5bkTnJTwiY0WZrtiLVihepd3Tk6hnnDoiF14NvHGiTHa2MkWitQdXw5-NTe4&sig=AHIEtbT7QwyCCp-r6JFzIDYD29eX1b1DA


